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(54) METHOD OF MANUFACTURING SILICON SINGLE CRYSTAL

(57)Abstract:
PROBLEM TO BE SOLVED: To manufacture a silicon single crystal wafer with the CZ method under stable condition which is capable of improving in electric performance such as oxidation high withstanding voltage surely without belonging to a hole rich V region, an OSF region, and a between lattice silicon rich I region.
SOLUTION: The method of manufacturing silicon single crystal wafer and silicon single crystal are characterized in that in the silicon single crystal water grown by the Czochralski method, in N region out side of OSF ring generated in ring state at the time of heat oxidizing process for all surfaces of the wafer, no defective region is existing which is to be detected by Cu deposition.

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CLAIMS

[Claim(s)]
[Claim 1] The silicon single crystal wafer characterized by being that in which the defective field which is an N field of the outside of OSF generated in the shape of a ring in the silicon single crystal wafer raised by the Czochrlski method when the whole wafer surface carries out thermal oxidation processing, and is detected by Cu deposition does not exist.
[Claim 2] The silicon single crystal wafer characterized by being N field of the outside of OSF generated in the shape of a ring in the silicon single crystal wafer raised by the Czochrlski method when the whole wafer surface carries out thermal oxidation processing, and being that to which nickel field which the defective field and precipitation of oxygen which are detected by Cu deposition cannot produce easily does not exist in the whole wafer surface.
[Claim 3] The manufacture approach of the silicon single crystal characterized by growing up a crystal in the defect-free field where the defective field which is an N field of the outside of OSF generated in the shape of a ring when thermal oxidation processing is carried out to the silicon single crystal wafer raised when a silicon single crystal was raised with the Czochrlski method, and is detected by Cu deposition does not exist.
[Claim 4] The manufacture approach of the silicon single crystal characterized by to control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when a silicon single crystal is raised with the Czochrlski method and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which a grids transition loop formation generates when a growth rate is dwindled further, and to raise a crystal.
[Claim 5] The manufacture approach of the silicon single crystal characterized by growing up a crystal in the field where nickel field which the defective field and precipitation of oxygen which are N field of the outside of OSF generated in the shape of a ring when thermal oxidation processing is carried out to the silicon single crystal wafer raised when a silicon single crystal was raised with the Czochrlski method, and are detected by Cu deposition cannot produce easily does not exist.
[Claim 6] The manufacture approach of the silicon single crystal characterized by to control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when a silicon single crystal is raised with the Czochrlski method and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which nickel field which precipitation of oxygen cannot produce easily when a growth rate is dwindled further generates, and to raise a crystal.
[Claim 7] The manufacture approach of the silicon single crystal indicated in any 1 term of claim 3 characterized by making the pull-up rate at the time of said crystal growth into 0.5 or more mm/min thru/or claim 6.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This inventions are not V field which is mentioned later, an OSF field, and which defective field of an I region, either, and relate to the manufacture approach of of the silicon single crystal wafer and silicon single crystal with the electrical property excellent in high pressure-proofing with which the oxide-film defect further detected by copper deposition processing is not formed, either.
[0002]
[Description of the Prior Art] In recent years, the quality demand to the silicon single crystal produced with the Czochrlski method (it is hereafter written as a CZ process) used as the substrate has been increasing with detailed-izing of the component accompanying high integration of a semiconductor circuit. The defect of a single crystal growth reason in which the oxide film proof-pressure property especially called grown-in (Grown-in) defects, such as FPD, LSTD, and COP, and the property of a device are worsened exists, and importance is attached to reduction of the consistency and size.
[0003] In explaining these defects, it explains being known generally about the factor which determines each concentration of the point defect of the hole mold first called the Vacancy (it may outline Vacancy and Following V) incorporated by the silicon single crystal, and the mold silicon point defect between grids called Interstitial-Si (it may outline Interstitial-Si and Following I) incorporated.
[0004] In a silicon single crystal, V fields are Vacancy, i.e., the crevice generated from lack of a silicon atom, and a field with many things like a hole. With an I region It is the thing of a field with many lumps of the rearrangement and the excessive silicon atom which are generated when a silicon atom exists in an excess. Between V field and an I region The neutral (it may outline Neutral and Following N) field without lack of an atom or an excess (few) will exist. And with [even if said grown-in defects (FPD, LSTD, COP, etc.) occur when V and I are in a condition / ****** / to the last, and it has the bias of some atoms] saturation [below], it has turned out that it does not exist as a defect.
[0005] The concentration of both this point defect is decided from the pull-up rate (growth rate) of the crystal in a CZ process, and relation with the temperature gradient G near [under crystal] the solid-liquid interface. The defect called OSF (an oxidation induction stacking fault, Oxidation Indused Stacking Fault) near [boundary] V field and an I region When it sees in the cross section of the perpendicular direction to a crystal growth shaft, being distributed in the shape of a ring (it being hereafter called an OSF ring) is checked.
[0006] The defect of these crystal growth reason is acquired as a defective distribution map as shown in drawing 7 , when a crystal orientation changes a growth rate from a high speed to a low speed with CZ pull-up machine with which the temperature gradient G near the solid-liquid interface used the large structure in a furnace (hot zone: it may be called HZ) during the usual crystal.
[0007] And a classification of the defect of these crystal growth reason calls V field the field where grown-in defects by which it is considered as the void reason to which hole type point defects gathered when a growth rate is a high speed comparatively, the above before and after 0.6 mm/min and, such as FPD, LSTD, and COP, exist in high density throughout the direction of the diameter of a crystal, for example, and these defects exist (line of drawing 7 R> 7 (A)). Moreover, when a growth rate is 0.6 or less mm/min, the field where an OSF ring is generated from the circumference of a crystal, the defect of ratios of length to diameter (Large Dislocation: the code of the dislocation loop between grids, LSEPD, LFPD, etc.) considered to be dislocation loop reasons by the outside of this ring exists in a low consistency with lowering of a growth rate, and these defects exist is

called the I region (it may be called a ratio-of-length-to-diameter field). Furthermore, if a growth rate is made into a low speed below 0.4 mm/min order, an OSF ring will condense and disappear at the core of a wafer, and the whole surface will serve as an I region (line of drawing 7 (c)).
[0008] Moreover, the existence of the field where neither FPD of a hole reason, LSTD, COP nor LSEPD of a dislocation loop reason and LFPD exist called N field to the outside of an OSF ring is discovered in the medium of V field and an I region in recent years. It is reported that this field is the I region side which is not so rich as there is almost no precipitation of oxygen by being in the outside of an OSF ring when oxygen precipitation heat treatment is performed and the contrast of a deposit is checked by X-ray observation etc., and LSEPD and LFPD are formed (line of drawing 7 (B)).
[0009] Since these N fields existed aslant to growth shaft orientations by the usual approach when a growth rate is lowered, they existed only in the part in the wafer side. About this N field, it has recited that a parameter called V/G which is the ratio of a pull-up rate (V) and a crystal solid-liquid interface shaft-orientations temperature gradient (G) determines the total concentration of a point defect by the Voronkov theory (V. V.Voronkov;Journal of Crystal Growth, 59 (1982) 625-643). When thought from this, only a crystal from which a core serves as an I region on the outskirts across N field in V field at a certain pull-up rate since the pull-up rate must be regularity and G has distribution in a field was obtained in the field.
[0010] Then, distribution of G within a field is improved and the crystal with which N field spread this N-field where that it is only slanting existed all over width at a certain pull-up rate when for example, the pull-up rate F was gradually pulled up with lowering can be manufactured now recently. Moreover, in order to expand the crystal of this whole surface N field in the die-length direction, if a pull-up rate when this N field spreads horizontally is maintained and pulled up, it can attain to some extent. Moreover, when adjusting the pull-up rate in consideration of G changing so that it might be amended and V/G might become fixed to the last as the crystal grew, as it is, the crystal used as a whole surface N field could be expanded also in the growth direction.
[0011] If this N field is classified further, there is a nickel field (field with much silicon between grids) contiguous to Nv field (field with many holes) contiguous to the outside of an OSF ring and an I region, and in Nv field, when thermal oxidation processing is carried out, there are many amounts of precipitation of oxygen, and it turns out that there is almost no precipitation of oxygen in nickel field.
[0012] However, as mentioned above, when thermal oxidation processing was carried out, in spite of having been a whole surface N field and having been the single crystal with which an OSF ring is not generated and FPD and ratio of length to diameter do not exist in the whole surface, it turned out that an oxide-film defect may occur remarkably. And this is the cause of degrading an electrical property like an oxide-film proof-pressure property, it is just inadequate that the conventional whole surface is N field, and the further improvement was desired.
[0013]
[Problem(s) to be Solved by the Invention] then, the thing by which this invention was made in view of such a trouble -- it is -- a hole -- rich V field, an OSF field, and the silicon between grids -- it belongs to neither of a rich I region, and aims at obtaining the silicon single crystal wafer by the CZ process which can raise electrical properties, such as oxide-film pressure-proofing, certainly under the stable manufacture condition.
[0014]
[Means for Solving the Problem] The silicon single crystal wafer which it succeeded in order that this invention might attain said object, and is applied to this invention is characterized by being that in which the defective field which is an N field of the outside of OSF generated in the shape of a ring, and is detected by Cu deposition does not exist, when the whole wafer surface carries out thermal oxidation processing in the silicon single crystal wafer raised by the Czochrlski method (claim 1).
[0015] Thus, the silicon single crystal wafer of this invention is a defect-free wafer with which the defective field which is an N field of the outside of OSF generated in the shape of a ring when the whole wafer surface carries out thermal oxidation processing, and is detected by especially Cu deposition does not exist, and turns into a silicon wafer of the high quality which does not degrade electrical properties, such as an oxide-film proof-pressure property, even if it produces a device.
[0016] And the silicon single crystal wafer which is the 2nd mode of this invention is characterized by being N field of the outside of OSF generated in the shape of a ring, when the whole wafer surface carries out thermal oxidation processing, and being that to which nickel field which the defective field and precipitation of oxygen

which are detected by Cu deposition cannot produce easily does not exist in the whole wafer surface in the silicon single crystal wafer raised by the Czochrlski method (claim 2).
[0017] Thus, when the whole wafer surface carries out thermal oxidation processing, it is N field of the outside of OSF generated in the shape of a ring, nickel field which the defective field and precipitation of oxygen which are detected by especially Cu deposition cannot produce easily is the defect-free wafer which does not exist in the whole wafer surface, and gettering capacity is also high [a wafer] while it does not degrade electrical properties, such as an oxide-film proof-pressure property, even if the silicon single crystal wafer of this invention produces a device.
[0018] Next, the manufacture approach of the silicon single crystal concerning this invention is characterized by growing up a crystal in the defect-free field where the defective field which is an N field of the outside of OSF generated in the shape of a ring when thermal oxidation processing is carried out to the silicon single crystal wafer raised when a silicon single crystal was raised with the Czochrlski method, and is detected by Cu deposition does not exist (claim 3).
[0019] And the manufacture approach of the silicon single crystal concerning this invention [when raising a silicon single crystal with the Czochrlski method] The growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when the growth rate of the silicon single crystal under pull-up is dwindled disappears, When a growth rate is furthermore dwindled, it is characterized by controlling to the growth rate between the growth rates of the boundary which a grids transition loop formation generates, and raising a crystal (claim 4).
[0020] According to these manufacture approaches, when thermal oxidation processing is carried out to the raised silicon single crystal wafer, it is N field of the outside of OSF generated in the shape of a ring, and the defect-free silicon single crystal wafer with which the defective field which degrades electrical properties, such as oxide-film pressure-proofing detected by especially Cu deposition, does not exist can be manufactured.
[0021] the 2nd mode of the manufacture approach of the silicon single crystal which furthermore apply to this invention characterize by to grow up a crystal in the field where nickel field which the defective field and the precipitation of oxygen which be N field of the outside of OSF generate in the shape of a ring when thermal oxidation processing be carry out to the silicon single crystal wafer raised when a silicon single crystal be raised with the Czochrlski method , and be detect by Cu deposition cannot produce easily do not exist (claim 5) .
[0022] In addition, the manufacture approach of the silicon single crystal concerning this invention [when raising a silicon single crystal with the Czochrlski method] The growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when the growth rate of the silicon single crystal under pull-up is dwindled disappears, When a growth rate is furthermore dwindled, it is characterized by controlling to the growth rate between the growth rates of the boundary which nickel field which precipitation of oxygen cannot produce easily generates, and raising a crystal (claim 6).
[0023] According to these manufacture approaches, when the whole wafer surface carries out thermal oxidation processing, it is N field of the outside of OSF generated in the shape of a ring, and nickel field which the defective field and precipitation of oxygen which are detected by Cu deposition cannot produce easily can manufacture the defect-free silicon single crystal wafer which does not exist in the whole wafer surface. Therefore, oxide-film pressure-proofing and gettering capacity can obtain a good crystal.
[0024] In these manufacture approaches, it is desirable to make the pull-up rate at the time of crystal growth into 0.5 or more mm/min (claim 7). Thus, the manufacture margin of 0.5 or more mm/min then the defect-free field of this invention, especially the field in which an oxygen sludge layer is formed expands the pull-up rate at the time of crystal growth, and adequate supply becomes possible.
[0025] Hereafter, although explained to a detail per this invention, this invention is not limited to these. In advance of explanation, lessons is taken from each vocabulary, and it explains beforehand.
1) K2 Cr 2O7 after cutting down a wafer from the silicon single crystal rod after growth and etching and removing a surface distortion layer with the mixed liquor of fluoric acid and a nitric acid in FPD (Flow Pattern Defect) A pit and a ripple pattern arise by etching a front face with the mixed liquor of fluoric acid and water (Secco etching). This ripple pattern is called FPD, and the defects of oxide-film pressure-proofing increase in number, so that the FPD consistency within a wafer side is high (refer to JP,4-192345,A).
[0026] 2) When the same Secco etching as FPD is performed, call SEPD (Secco Etch Pit Defect) a thing without FPD, a call, and a flow pattern for the thing accompanied by a flow pattern (flow pattern) with SEPD.

When it is thought in this that large SEPD (LSEPD) 10 micrometers or more originates in a rearrangement cluster and a rearrangement cluster exists in a device, a current leaks through this rearrangement and it stops achieving the function as a P-N junction.
[0027] 3) Cut down a wafer from the silicon single crystal rod after growth, and carry out cleavage of the wafer to LSTD (Laser Scattering Tomography Defect) after etching and removing a surface distortion layer with the mixed liquor of fluoric acid and a nitric acid. Incidence of the infrared light can be carried out from this cleavage plane, and the scattered light by the defect which exists in a wafer can be detected by detecting the light which came out from the wafer front face. About the scatterer observed here, it is an institute etc., there is already a report, and it is regarded as the oxygen sludge (Jpn.J.Appl.Phys. Vol.32, P3679, 1993 reference). Moreover, the result that it is the void (hole) of octahedron is also reported by the latest research.
[0028] 4) the defect which becomes the cause of degrading oxide film pressure-proofing of the core of a wafer, with COP (Crystal Originated Particle) -- it is -- Secco -- by SC-1 washing (washing by the mixed liquor of NH4 OH:H2 O2:H2 O=1:1:10), the defect set to FPD if dirty works as a selection etching reagent, and is set to COP. The diameter of this pit is investigated with light scattering measurement by 1 micrometer or less.
[0029] 5) It is the defect which there are LSEPD, LFPD, etc. in ratio of length to diameter (Large Dislocation: code of the dislocation loop between grids), and is considered to be a dislocation loop reason. A large thing 10 micrometers or more is said that LSEPD described above also in SEPD. Moreover, also in FPD which LFPD described above, the magnitude of a head pit says a large thing 10 micrometers or more, and it is considered the dislocation loop reason also here.
[0030] 6) The Cu deposition method measures the location of the defect of a semiconductor wafer to accuracy, raises the sensitiveness to the defect of a semiconductor wafer, measure it to accuracy also to a more detailed defect, and it is an appraisal method of the wafer which can be analyzed.
[0031] The concrete assessment approach of a wafer destroys the insulator layer on the defective part which was made to form the insulator layer of predetermined thickness and was formed near the front face of said wafer on the wafer front face, and deposits electrolysis matter, such as Cu, to a defective part (deposition). That is, the Cu deposition method is an appraisal method using a current flowing to the part to which the oxide film has deteriorated, and Cu ion serving as Cu and depositing in the liquid with which Cu ion is dissolved, if potential is impressed to the oxide film formed in the wafer front face. It is known that defects, such as COP, exist in the part by which an oxide film tends to deteriorate.
[0032] The defective part of the wafer by which Cu deposition was carried out can be analyzed on the bottom of a condensing LGT, or a direct target with the naked eye, can evaluate the distribution and consistency, and can also check microscope observation, a transmission electron microscope (TEM), or a scanning electron microscope (SEM) further.
[0033]
[Embodiment of the Invention] When this invention persons investigated in the detail about the boundary neighborhood of V field and an I region about the silicon single crystal growth by the CZ process, they found out neutral N field where the outside of an OSF ring has few FPD(s), LSTD(s), and COP remarkably, and ratio of length to diameter does not exist in it in the medium of V field and an I region, either. And if this N field is classified further, there is a nickel field (field with much silicon between grids) contiguous to Nv field (field with many holes) contiguous to the outside of an OSF ring and an I region, and in Nv field, when thermal oxidation processing is carried out, there are many amounts of precipitation of oxygen, and it has turned out that there is no precipitation of oxygen in nickel field.
[0034] However, even if it raised the crystal in the above-mentioned N field, there is what has bad oxide-film pressure-proofing, and the cause was not found well. Then, when this invention person etc. investigated in the detail further about N field by the Cu deposition method, he is N field of the outside of an OSF field, and discovered that a part of Nv field which the precipitation of oxygen after precipitation heat treatment tends to generate had the field which the defect detected by Cu deposition processing generates remarkably. And this traced that it was the cause of degrading an electrical property like an oxide-film proof-pressure property.
[0035] Then, if a field without the defective field which is an N field of the outside of this OSF and is detected by Cu deposition can be extended all over a wafer, while said various grown-in defects cannot be found, the wafer which can improve an oxide-film proof-pressure property etc. certainly will be obtained.
[0036] this invention person etc. conducted the following experiments, asked for a growth rate and the relation

of defective distribution, raised the single crystal rod based on the result, and evaluated the oxide-film proof-pressure property of a wafer.
(Experiment 1) MCZ shown in the equipment A of drawing 2 (a), and the equipment B of drawing 2 (b) -- law -- among crystal pulling equipment (horizontal magnetic field impression), Equipment A charged 150kg of raw material polycrystalline silicon to the 24 inch quartz crucible, and Equipment B charged 160kg of raw material polycrystalline silicon to 26 inch quartz RUTSUPO, and it pulled up the silicon single crystal of the diameter of 8 inches (diameter of 200mm), and bearing <100> with each equipment. When pulling up a single crystal, it controlled to dwindle a tail from a crystal head in the range of 0.7 mm/min to 0.3 mm/min, applying a growth rate. Moreover, the single crystal was produced so that the oxygen density of a wafer might serve as 22 - 23ppma (ASTM'79 value).
[0037] And as shown in drawing 3 (a) and (b), it applied to the tail from the head of the crystal pulled up, vertical division cutting was carried out in the crystal orientation, and the four wafers sample was produced. Among four sheets, three sheets investigated the distribution situation of each field of V field, an OSF field, and an I region, the distribution situation of FPD and LEP, and the OSF generating situation by OSF heat treatment by WLT (wafer life time) measurement (measuring instrument: SEMILAB WT-85) and SEKOETCHINGU, and checked the growth rate of each field boundary. One in the sample which furthermore carried out vertical division cutting in the crystal orientation ****-omission-processes a wafer configuration with a diameter of 6 inches, as shown in drawing 3 (c), and it is 1. After mirror plane processing finishing, after ** formed the thermal oxidation film in the wafer front face, it performed Cu deposition processing and checked the distribution situation of an oxide film defect.
[0038] The assessment procedure of the wafer in this experiment and detail of an assessment result are given below.
(1) Vertical division cutting of the single crystal rod pulled up was carried out after block cutting in vertical crystal orientation at the die length for 10cm of every crystal orientation, and four samples of about 2mm thickness were produced.
(2) In the wafer heat treating furnace, 800 degrees C and 4-hour (under nitrogen-gas-atmosphere mind) heat treatment were performed after heat treatment to the bottom of nitrogen-gas-atmosphere mind, it cooled after that after 1000 degrees C and 16-hour (under dry oxygen ambient atmosphere) heat treatment, and the 1st in the above-mentioned sample created the map of wafer life time (WLT) by SEMILAB-85 for 620 degrees C and 2 hours (refer to drawing 4 (a) and (b)). Moreover, the 2nd sheet gave SEKOETCHINGU after mirror etching, and observed distribution of FPD and LEP. And the 3rd sheet, it removed the oxide film, and checked the distribution situation of OSF. [after OSF heat treatment] Each field of V field, an OSF field, and an I region was pinpointed from these results, and the growth rate of each boundary was investigated.
[0039] The growth rate (refer to drawing 4 (a)) of each boundary of the single crystal pulled up with Equipment A (drawing 2 (a)) was as follows.
V field / OSF field boundary: 0.484 mm/min OSF dissipation boundary: 0.472 mm/min Cu deposition defective dissipation boundary: 0.467 mm/min Non-depositing N(nickel) field / I region boundary: 0.454 mm/min, [0040] The growth rate (refer to drawing 4 (b)) of each boundary of the single crystal pulled up with Equipment B (drawing 2 (b)) is as follows.
V field / OSF field boundary: 0.596 mm/min OSF dissipation boundary: 0.587 mm/min Cu deposition defective dissipation boundary: 0.566 mm/min A deposit N(Nv) field / nickel field boundary: 0.526 mm/min nickel field / I region boundary : 0.510 mm/min, [0041] (3) the sample which carried out vertical division cutting in the crystal orientation of the single crystal rod of the above (1) -- inner -- **** omission processing (refer to drawing 3 (c)) of remaining one sheet was carried out to the wafer configuration with a diameter of 6 inches, Cu deposition processing after thermal oxidation film formation was performed to the wafer front face after mirror plane processing finishing, and the distribution situation of an oxide film defect was checked. The assessment conditions are as follows.
1) Oxide film : 25nm 2 electrolysis reinforcement: For [6 MV/cm and 3 electrical-potential-difference impression time amount:] 5 minutes.
[0042] Drawing is shown as a result of Cu deposition's estimating Nv field to drawing 5 . Drawing 5 (a) shows defective distribution of Nv field without the defect according [(b)] defective distribution of the defective field generated by Cu deposition to Cu deposition. Drawing 6 (a) is as a result of [of Nv field which the defect

generated in Cu deposition] assessment, and (b) is as a result of [of Nv field which a defect did not generate by Cu deposition] assessment.
[0043] It turns out that the defective field detected by Cu deposition which an oxide film defect tends to produce all over Nv field which precipitation of oxygen tends to produce from the above result among N fields which exist in an OSF outside exists. In this field, in spite of being Nv field, oxide-film pressure-proofing is not necessarily good. It turns out that a result which can be satisfied also with the same Nv field of oxide-film pressure-proofing in Nv field without the defective field detected by this Cu deposition on the other hand is brought.
[0044] (Experiment 2) Next, based on the above-mentioned result, using Equipment B (drawing 2 (b)), it was N field of an OSF outside, it was processed into the wafer of mirror finish from the crystal which controlled the growth rate and pulled up so that the field which does not include the field and nickel field which precipitation of oxygen cannot produce further easily which is not Cu deposition defective field (Dn field), either could be aimed at, and the oxide film proof pressure property was evaluated. In addition, the C-mode Measuring condition is as follows.
1) Oxide film : 25nm Two measuring electrode: The Lynn dope polish recon and 3 electrode-surface product:8mm2 4 judging current: 1mA/cm2.
Consequently, oxide film proof-pressure level was 100% of rate of an excellent article.
[0045] this invention person etc. repeats examination wholeheartedly, after being based on the knowledge acquired in the above experiment, and he hits on an idea to this invention. The manufacture approach of the 1st silicon single crystal of this invention is characterized by growing up a crystal in the defect-free field where the defective field which is an N field of the outside of OSF generated in the shape of a ring when thermal oxidation processing is carried out to the raised silicon single crystal wafer, and is detected by Cu deposition does not exist.
[0046] It will control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when this approach was explained based on drawing 1 and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which a grids transition loop formation generates when a growth rate is dwindled further, and a crystal will be raised.
[0047] The wafer cut down from the single crystal rod raised by the approach described above turns into a defect-free silicon single crystal wafer with which the defective field which is an N field of the outside of OSF generated in the shape of a ring when the whole wafer surface carries out thermal oxidation processing, and is detected by Cu deposition does not exist at all.
[0048] Next, when the 2nd manufacture approach carries out thermal oxidation processing to the raised silicon single crystal wafer, it is N field of the outside of OSF generated in the shape of a ring, and it is characterized by growing up a crystal in the field where nickel field which the defective field and precipitation of oxygen which are detected by Cu deposition cannot produce easily does not exist.
[0049] It will control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when this approach was explained based on drawing 1 and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which nickel field which precipitation of oxygen cannot produce easily when a growth rate is dwindled further generates, and a crystal will be raised.
[0050] The wafer produced from the single crystal rod raised by this manufacture approach is N field of the outside of OSF generated in the shape of a ring, when the whole wafer surface carries out thermal oxidation processing, and nickel field which the defective field and precipitation of oxygen which are detected by Cu deposition cannot produce easily can use it as the defect-free silicon single crystal wafer which does not exist in the whole wafer surface.
[0051] Since this wafer is Nv field altogether, when it is heat-treated under nitrogen and a dry oxygen ambient atmosphere all over a defect-free field excluding nickel field which precipitation of oxygen cannot produce easily, an oxygen sludge layer is formed into bulk. Therefore, the silicon single crystal wafer produced from this field has the gettering capacity which oxide-film pressure-proofing etc. is not only good, but was excellent.
[0052] When producing this invention article furthermore, when using CZ pull-up equipment of quenching structure which can be raised with the growth rate of 0.5 or more mm/min, the defect-free field of this

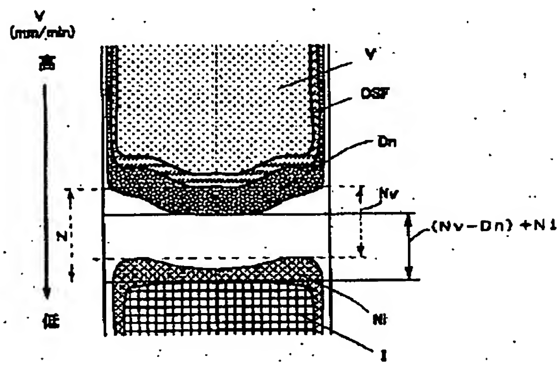
invention, especially the field (Nv-Dn) in which an oxygen sludge layer is formed were able to expand more the silicon single crystal used as a raw material, and manufacture top stability was able to be maintained.
[0053] And the shaft-orientations temperature gradient Gc of the crystal solid-liquid interface in the crystal center section is small. Although it was not able to mass-produce easily since the growth rate margin of this invention article was less than 0.02 mm/min when it was CZ process pull-up equipment by which the growth rate of 0.5 mm/min is not exceeded at the time of defect-free field manufacture of this invention Gc was large, and in case it was defect-free field manufacture of this invention, when it was CZ process pull-up equipment which can attain the growth rate of 0.5 or more mm/min, the growth rate margin of this invention article is 0.02 or more mm/min, and was able to attain the maximum about 0.05 mm/min. When this invention article was especially manufactured with the growth rate of 0.5 or more mm/min as mentioned above, it turned out that the growth rate margin of the field where an oxygen sludge layer is formed into BARUGU after heat treatment in nitrogen and a dry oxygen ambient atmosphere can be expanded easily.
[0054] Drawing 2 (a) and (b) explain the example of a configuration of the crystal pulling equipment by the CZ process finally used by this invention. As shown in drawing 2 (a), this crystal pulling equipment 30 The pull-up room 31, the crucible 32 prepared all over the pull-up room 31, and the heater 34 arranged around a crucible 32, It has the reel style (not shown) which rotates or rolls round the crucible maintenance shaft 33 made to rotate a crucible 32 and its rolling mechanism (not shown), the seed chuck 6 holding the seed crystal of silicon, the wire 7 that pulls up a seed chuck 6, and a wire 7, and is constituted. A quartz crucible is prepared in the side in which a crucible 32 holds the silicon melt (molten bath) 2 of the inside, and the graphite crucible is prepared in the outside. Moreover, the heat insulator 35 is arranged around [outside] the heater 34.
[0055] Moreover, in order to set up the manufacture conditions in connection with the manufacture approach of this invention, the annular graphite cylinder (thermal insulation plate) 9 is formed. Moreover, what was shown in drawing 2 (b) has formed the annular outside heat insulator 10 in the periphery of the solid-liquid interface 4 of a crystal. This outside heat insulator 10 prepares spacing of 2-20cm between that soffit and surface of hot water 3 of silicon melt 2, and is installed in it. Furthermore, coolant gas may be sprayed or the tubed cooling system which interrupts radiant heat and cools a single crystal may be formed. Independently, by installing the magnet which is not illustrated in the horizontal outside of the pull-up room 31, and impressing magnetic fields, such as a horizontal direction or a perpendicular direction, to silicon melt 2, the convection current of melt is controlled and, recently, the so-called MCZ method for measuring the stable growth of a single crystal is used in many cases.
[0056] Next, the single-crystal-growth approach by above crystal pulling equipment 30 is explained. First, within a crucible 32, the high grade polycrystal raw material of silicon is heated more than the melting point (about 1420-degreeC), and is dissolved. Next, the head of seed crystal is made contacted or immersed in the surface abbreviation core of melt 2 by beginning to roll a wire 7. Then, while rotating the crucible maintenance shaft 33 in the proper direction, single crystal growth is started by rolling round rotating a wire 7 and pulling up seed crystal. Henceforth, the single crystal rod 1 of an approximate circle column configuration can be obtained by adjusting a pull-up rate and temperature appropriately.
[0057] In this case, in this invention, especially in order to attain the object of this invention, as shown in drawing 2 (a) or drawing 2 R> 2 (b), in the periphery space of the liquefied part in the single crystal rod 1 on the surface of hot water of the pull-up room 31, it is important to have formed the annular graphite cylinder (thermal insulation plate) 9 and the outside heat insulator 10 so that the temperature region from the melting point of the crystal near the surface of hot water to 1400 degrees C could be controlled.
[0058] Namely, what is necessary is to form the outside heat insulator 10 in the pull-up room 31, and just to set spacing on this soffit and the front face of melt as 2-20cm, in order to control whenever [this furnace temperature], for example, as shown in drawing 2 (b). If it carries out like this, whenever [furnace temperature] is also controllable so that the difference of the temperature gradient Gc of a crystal center part [**/cm] and the temperature gradient germanium of a crystal circumference part becomes small, for example, the direction of the temperature gradient of the crystal circumference becomes lower than a crystal center. This outside heat insulator 10 is in the outside of the graphite cylinder 12, and has formed the heat insulation cylinder 11 also inside the graphite cylinder 12. Moreover, the graphite cylinder 12 top is connected with the metal cylinder 13, and a cooling dome 14 is on it, and it is pouring and carrying out forced cooling of the cooling medium.

[0059] When the silicon single crystal wafer which slices the silicon single crystal manufactured by the manufacture approach of the silicon single crystal described above, and is obtained carries out thermal oxidation processing to a wafer, it is a defect-free wafer with which the defective field which is an N field of the outside of OSF generated in the shape of a ring, and is detected by Cu deposition does not exist. Or when the whole wafer surface carries out thermal oxidation processing, it is N field of the outside of OSF generated in the shape of a ring, and nickel field which the defective field and precipitation of oxygen which are detected by Cu deposition cannot produce easily is the defect-free wafer which does not exist in the whole wafer surface.
[0060] In addition, this invention is not limited to the above-mentioned operation gestalt. The above-mentioned operation gestalt is instantiation, and no matter it may be what thing which has the same configuration substantially with the technical thought indicated by the claim of this invention, and does the same operation effectiveness so, it is included by the technical range of this invention.
[0061] For example, in the above-mentioned operation gestalt, although the example was given and explained per when a silicon single crystal with a diameter of 8 inches was raised, this invention is not limited to this but can be applied also to the diameter of 10-16 inches, or the silicon single crystal beyond it. Moreover, it cannot be overemphasized that this invention is applicable also to the so-called MCZ method for impressing a level magnetic field and length magnetic field, a cusp field, etc. to silicon melt.
[0062]
[Effect of the Invention] As explained above, according to this invention, it is not V field, an OSF field, and which defective field of an I region, either, and the silicon single crystal wafer with the electrical property excellent in high pressure-proofing with which the oxide-film defect further detected by Cu deposition processing is not formed, either can be supplied stably.

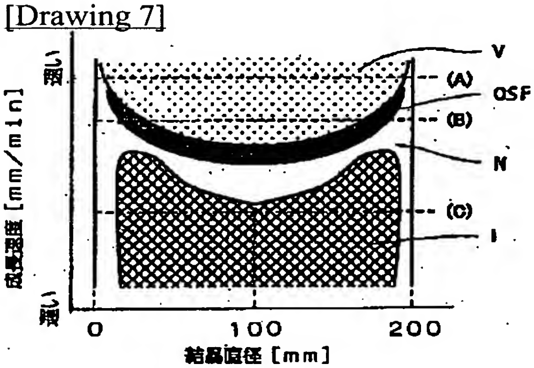
[Translation done.]

DRAWINGS

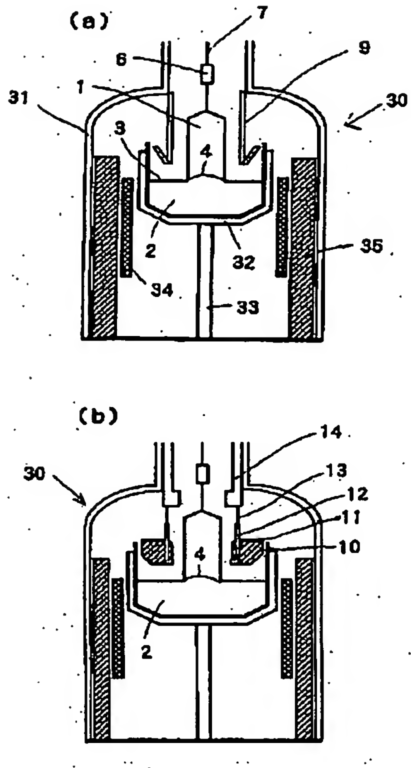
[Drawing 1]



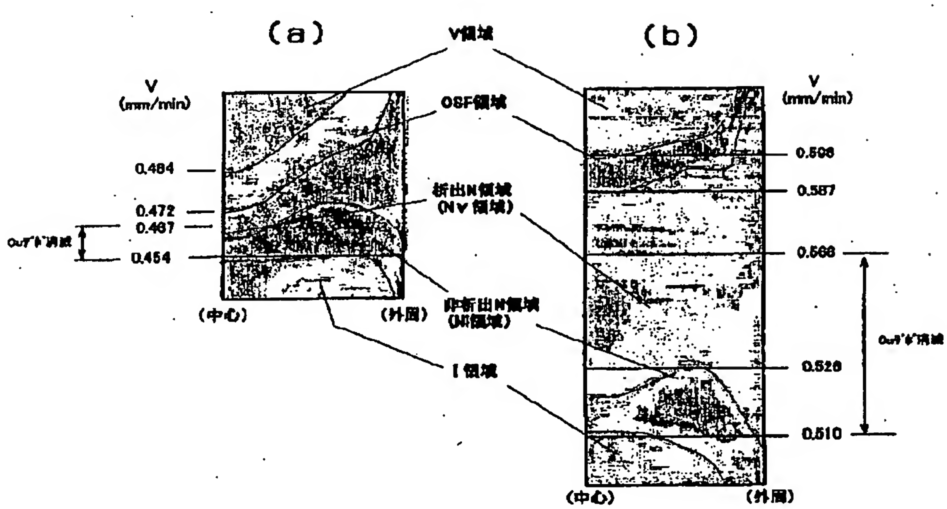
[Drawing 7]



[Drawing 2]

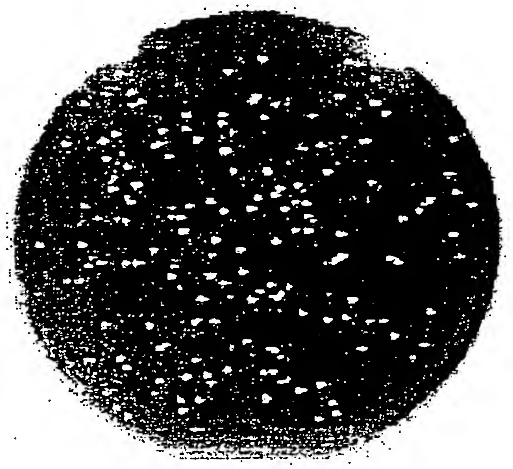


[Drawing 4]

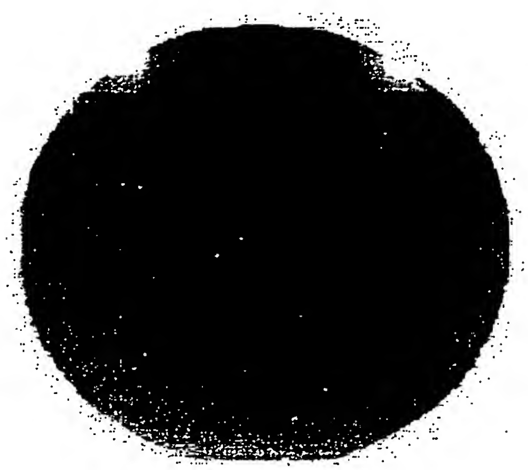


[Drawing 5]

(a)

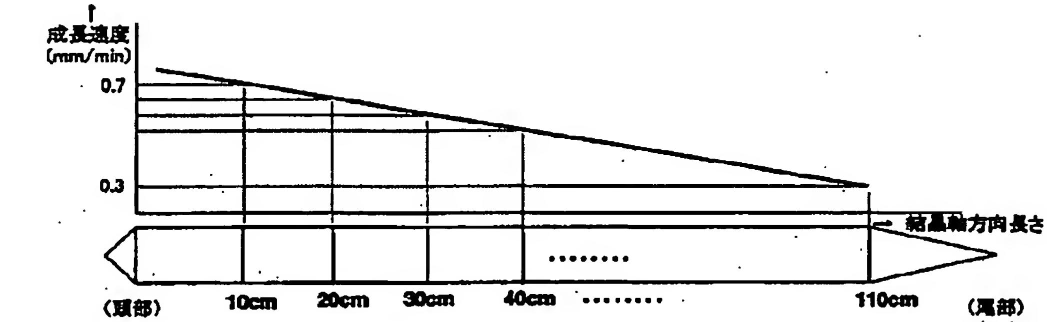


(b)

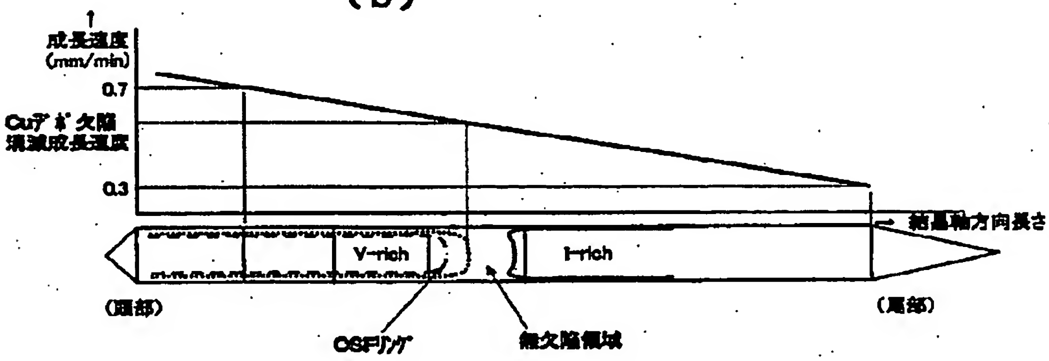


[Drawing 3]

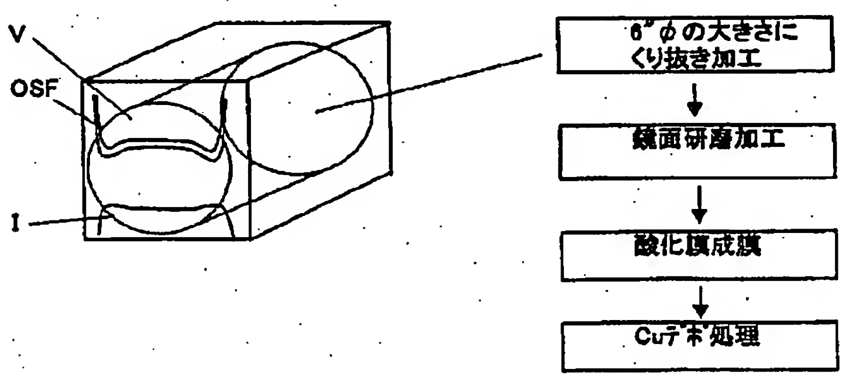
(a)



(b)

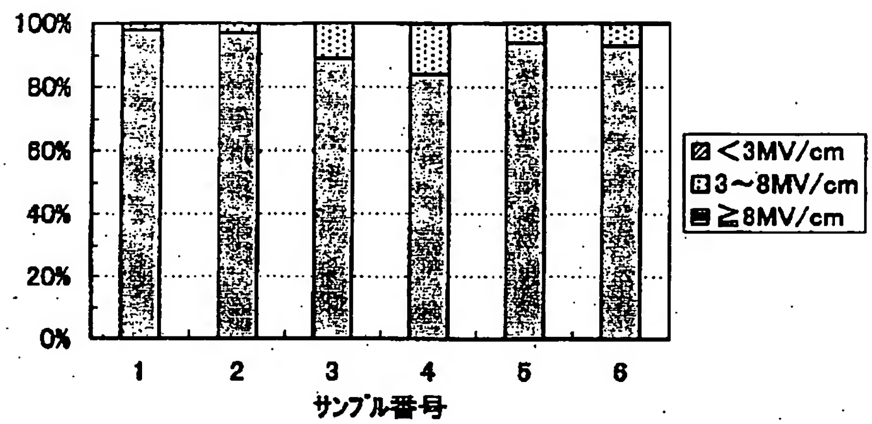


(c)

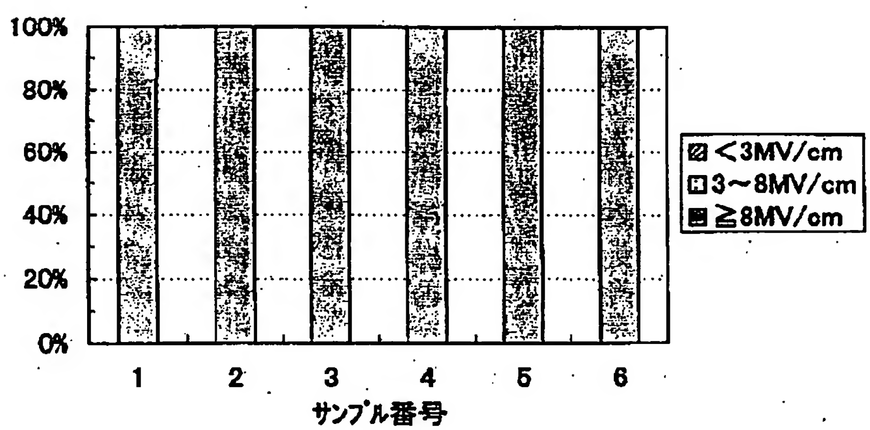


[Drawing 6]

(a)



(b)



[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Category partition] The 1st partition of the 3rd category
[Publication date] July 30, Heisei 15 (2003. 7.30)

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[Annual volume number] Open patent official report 14-2011
[Application number] Application for patent 2000-403127 (P2000-403127)
[The 7th edition of International Patent Classification]

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C30B  29/06    502
H01L  21/208
21/66
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[FI]

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C30B  29/06    502 J
H01L  21/208       P
21/66        N
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[Procedure amendment]
[Filing Date] April 25, Heisei 15 (2003. 4.25)
[Procedure amendment 1]
[Document to be Amended] Description
[Item(s) to be Amended] Claim 4
[Method of Amendment] Modification
[Proposed Amendment]
[Claim 4] The manufacture approach of the silicon single crystal characterized by to control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when a silicon single crystal is raised with the Czochrlski method and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which the dislocation loop between grids generates when a growth rate is dwindled further, and to raise a crystal.
[Procedure amendment 2]
[Document to be Amended] Description
[Item(s) to be Amended] 0010
[Method of Amendment] Modification
[Proposed Amendment]
[0010] Then, distribution of G within a field is improved and the crystal with which N field spread this N-field where that it is only slanting existed all over width at a certain pull-up rate when for example, the pull-up rate V was gradually pulled up with lowering can be manufactured now recently. Moreover, in order to expand the crystal of this whole surface N field in the die-length direction, if a pull-up rate when this N field spreads horizontally is maintained and pulled up, it can attain to some extent. Moreover, when adjusting the pull-up rate

in consideration of G changing so that it might be amended and V/G might become fixed to the last as the crystal grew, as it is, the crystal used as a whole surface N field could be expanded also in the growth direction.
[Procedure amendment 3]
[Document to be Amended] Description
[Item(s) to be Amended] 0019
[Method of Amendment] Modification
[Proposed Amendment]
[0019] And the manufacture approach of the silicon single crystal concerning this invention, It is characterized by controlling to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when a silicon single crystal is raised with the Czochrlski method and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which the dislocation loop between grids generates when a growth rate is dwindled further, and raising a crystal (claim 4).
[Procedure amendment 4]
[Document to be Amended] Description
[Item(s) to be Amended] 0041
[Method of Amendment] Modification
[Proposed Amendment]
[0041] (3) the sample which carried out vertical division cutting in the crystal orientation of the single crystal rod of the above (1) -- inner -- **** omission processing (refer to drawing 3 (c)) of remaining one sheet was carried out to the wafer configuration with a diameter of 6 inches, Cu deposition processing after thermal oxidation film formation was performed to the wafer front face after mirror plane processing finishing, and the distribution situation of an oxide film defect was checked.
The assessment conditions are as follows.
1) Oxide film : 25nm 2 field strength: 6 MV/cm,
3) Electrical-potential-difference impression time amount : for 5 minutes.
[Procedure amendment 5]
[Document to be Amended] Description
[Item(s) to be Amended] 0046
[Method of Amendment] Modification
[Proposed Amendment]
[0046] It will control to the growth rate between the growth rate of the boundary where the defective field detected by Cu deposition which remains after OSF ring dissipation when this approach was explained based on drawing 1 and the growth rate of the silicon single crystal under pull-up is dwindled disappears, and the growth rate of the boundary which the dislocation loop between grids generates when a growth rate is dwindled further, and a crystal will be raised.

[Translation done.]